Inside a Smoother Running Engine,

An American Giant Transforms Itself

J. Nicholas Edwards

The saga of Briggs and Stratton, in many ways, is a traditional American industrial success story. Founded in 1909 to produce an engine for the burgeoning automotive industry, it grew through two world wars to become the largest and best known manufacturer of air-cooled gasoline engines in the world.

During the late 1970s the company began to feel the challenge of global competition in its engine operations. The response was a long-term program to improve not only engine performance but also to increase the quality and reliability of engines that already had a reputation for high quality/ dependability. This article highlights how Briggs and Stratton is meeting this challenge and some of the key players in this effort.

One major player in the transformation was Rolland "Mac" McCulloch who, starting in 1979, cajoled, developed training material, and eventually became a key participant in the Briggs & Stratton resurgence into world class competitiveness. For the past 14 years Mac also spent time improving repetitive manufacturing operating systems, and assisting in JIT pilots on the Vanguard line and in the Lock division. In 1979 he became the founding chairman of the Repetitive Manufacturing Group of APICS which became in 1985 the Association for Manufacturing Excellence.® He continued to be a founding director of AME until his retirement.

Briggs and Stratton Milwaukee, WI

$1 billion annual sales

5970 employees in Engine Operations

2115 employees in the Large Engine Division (LED)

History

Briggs and Stratton, the world's largest manufacturer of air-cooled gasoline engines and automobile locks and keys is headquartered in Milwaukee, WI where it was founded. The company, which celebrated its 80th year in 1989, has been closely entwined with American growth in products powered by small engines for lawn and garden equipment, generators, and pumps, virtually anything where portable power was essential.

Briggs and Stratton suffered its first-ever loss in 1989. The company responded to the challenge with a two-pronged attack, one to broaden the line and the second to improve the quality, delivery speed, cost, and flexibility of its operations.

The approach used for the broader line included offering products for three major markets — the value market, the mid-market, and the high-performance market, each of which was structured to meet different goals. The value market was targeted to price, few features, and low-cost. The mid market was targeted for features,

Figure 1. Left to right: Paul Arndt, manager Plant 5; Bob Ehmke, manager Plant 3 (retired); Gary Zingler, manager Plant 4; and Dudley Grahek, manager Plant 1.

design, and style. Finally, the high-performance market was targeted to performance, service, and new technology. This three-pronged thrust has been well received for both the design and market considerations.

The engine plants were reorganized in 1989 into five focused business units:

1. The Large Engine Division for the five to 18 horsepower single and twin cylinder engines for riding lawn and garden equipment, generators, and pumps.
2. The Small Engine Division for the three and one-half to five horsepower engines primarily for portable lawn and garden equipment.
3. Vanguard Division making premium single and twin overhead valve cylinder products for heavy-duty, commercial applications, and premium lawn garden equipment.
4. The Castings Division making iron products for all divisions.
5. The Die Cast Division making the major aluminum components for Milwaukee-produced large, small, and Vanguard engines.

World Class Manufacturing at the Large Engine Division (LED)

The Large Engine Division (LED) is organized under Vice President and General Manager Greg Socks. Recognizing that LED manufacturing had to change to remain a leader in the markets they served, Greg asked Mac McCulloch to help implement the Toyota Production System in the LED.

In April 1990, a seven-person Focused Factory Improvement Team formed, including six key LED players: Greg Socks; Bob Ehmke, plant manager, now retired; Neil DeCloux, production control manager; John Edwards, manufacturing engineer; Clay Jacobsen, team facilitator; and Ken Swaitzke, assembly manager, now retired. The outside "ringer" to the group was Mac McCulloch with the unusual job of manager of JIT technology for information systems. He served as the internal consultant. The team charter was to develop a way of going to "one-piece flow," that is, to take one engine through the entire manufacturing process without going to any batch steps. They recommended the formation of five focused factories based on product horsepower.

The plan was that each focused factory would be responsible for machining, assembly, painting, testing, and shipping its product with full responsibility for leadtime reduction (from weeks to hours), quality preventive maintenance, and cost control. Each factory was designed to be at most a two-shift operation with a maximum of 500 employees per factory, so that communications would be greatly improved. Any small volume components such as prepainted parts, punch press, and other miscellaneous small parts that did not fit the product and process focus of a focused factory were included as part of a general LED component operation.

In the initial stages of focused factory designs, Jim Wier, executive vice president of operations and both Greg's and Mac's boss, asked how the program was going. Mac's response was that progress was being made and to expect leadtimes and inventory to tumble. Mac then mentioned that they would need some capital to replace old machines. Jim's comment, "I'll give you $.50 on every $1.00 you permanently take out of inventory!" spawned a response from Mac, "We've gotta get better — productivity and inventory reduction — before we can get better — in new equipment etc." Two years later Mac kidded Jim by saying, "Where's my $5 million for equipment; we have taken out over $10 million in inventory!"

Early in the planning for focused factory implementation meetings were held with the Union Committee highlighting the significant reorganization plans, and the impact these changes would likely have on operating personnel. The committee members were invited to participate in the initial JIT training courses, as well as meet the LED team to answer questions and concerns. A series of all-day meetings began the breakdown of barriers that existed between union and management.

Alma Leatherwood of the carburetor assembly area commented, "This divisionalization will create a state of competitiveness in the company the likes of which we have never seen. Top management will have a clear picture what is profitable and what is not. Everyone, including myself, will be called to do and know more." As she better understood the focused factory concept, Alma went one step further and "commissioned" a drawing by fellow employee Bill Binet to highlight the elimination of waste. (See illustration at lower right.)

Alma's remarks, though not atypical, were not universally felt by all employees. Some were concerned that jobs might be lost if work was subcontracted out. Others thought these divisions would become destructively competitive.

The net result of this focused factory strategy was that the employees became multi-functional (able to operate many pieces of equipment in the factory). Many employees received an extensive "hands-on" training program developed by Mac based on David Lu's *Kanban Just-In-Time at Toyota*. Eight sessions of two hours each were held to explain the Toyota production system, Jidoka (fail-safing), construction of standard operations, and the use of standard operating tools. Within these broad headings were discussions of JIT philosophy, flow production and takt time, Kanbans, Kaizen, automation, understanding and separating man's and machine's work, all of which were essential to improve quality and reduce costs.

Team members learned the meaning of "takt time," the "drumbeat" of the focused factory. For example, if 1400 engines were to be built in two shifts (960 minutes) the takt time, or drumbeat, is 41 seconds (960 min. x 60 sec./min. divided by 1400 or 41 seconds) which is how frequently an engine must be completed off the assembly line. As a support text for systems impact, the teams also relied on Monden's *Toyota Production System*.

One of the earlier courses covered the concept of cell designs. Some attendees started to criticize the concept, saying they would become "walking zombies." Leora Smith, working the 17/19 cover cell, spoke up, "I've been working in a cell for six months now, and don't start knocking it until you know what it is like!"

As the management team, setup men, and the supervisors were trained, an overall plant layout for the five focused factories was developed, bringing machining equipment significantly closer together to help achieve the one-piece flow. One requirement of the plant re-layout was that any move could not interrupt any production or supply to the customer. The implementation solution was to create space or a "hole" on the manufacturing floor, then to move the cell to that "hole" on the manufacturing floor. The next step was to move a cell to that "hole" opening up another hole and so forth, until

Figure 2. *LED Staff, pictured from left to right. Back row: Jeff Futrell, Neil DeCloux. Middle row: Steve Tkachuk, Dan Klika, Ed Bednar, Todd Martin, Greg Socks. Front row: Judy Galewski and a Briggs and Stratton 5 HP air-cooled engine.*

... what once had been a two-week, 20-step crankshaft machining process with all the inherent queues became a series of machines side by side where one crankshaft went through the entire process in ***under 30 minutes****.*

all moves were complete over a two-plus year period from 1991 to 1993.

Launching the Cells, Winning Support

The real starting point for cell designs began when Mac, having been to Productivity Inc.'s course, "Five Days and a Night" encouraged Mike Krawezyk, a quality engineer, and Todd Jernberg, a quality control foreman who had come up through the ranks, to attend this same course in the spring of 1990. Mike was chartered to develop the first cell, the model 17/19 cover cell. He commented, "I'm not an MTM (Measurement Time Motion) specialist, so I had to start by breaking down the work into a sequence of events to the nearest second with a watch!" Disbelieving IEs teased him, "Do you use Mickey Mouse watches for these standards?" He responded that you had to have a watch to get into his club. "People really rejected change, as the emphasis was now on value-added work, not all work!"

Mike's next step was his "Train in the Station" theme, "The train is leaving and tickets are for sale. If you don't buy a ticket you'll miss a wonderful journey!' We had a few takers and it was jokingly called "The Train Ride to Disaster."

The implementation of the 17/19 Cover Cell was notable because it became in time a multi-part cell where three employees machine eight different parts. The unique characteristic is that they are always machining two part numbers at a time, one cylinder head along with one cover.

When a machinery cell came together the operators were an integral part of the cell implementation. When a cell began production there had to be a plan to reduce the WIP inventory. What once had been a two-week, 20-step crankshaft machining process with all the inherent queues, for example, became a series of machines side by side where one crankshaft went through the entire process in under 30 minutes.

Based on the experience of these early cells, the overall implementation took approximately two months per cell. With experience of the "Five Days and a Night course," Mac revised his course to a five-day "Make it Happen Workshop" that created a cell in five days following the ten steps shown in the accompanying box on this page.

When another session started a new cell, the prior subteam and team leaders became the trainers for the new workshop.

Todd Jernberg's first cell after the "Five Days and a Night" course was Model 40/42 cylinder cell. He commented, "I was scared to death — I didn't think a one-piece cell was possible on this line due to a lack of equipment reliability. We had to design a cell that could handle multiple volumes per shift of 300, 375, and 450 cylinders, due to the changing demands on this line. The cell was also big, 30 ft. x 90 ft., because the equipment was physically large, in order to handle the twin cylinder castings. Until I took the course, I believed the only way to achieve anything was to'pistol whip'employees to get the work out, and I wasn't going to run this place from some book!"

This cell was a challenge for Todd. Six months after implementation the cell was still not achieving the quality, uptime, and volumes that were expected. In a factory meeting with plant managers, Mac and Todd, there was great clamor to revise the staffing for the cell, because they could not achieve the required unit output. Todd "held his guns" because he had been a former operator. By reviewing the teams' work practices on handling parts and fixturing he was able to convince them that the required output was feasible. They now can machine far more than the required output.

Ten Steps to Creating a Cell

1. Train the cell team in JIT concepts in a 1 1/2 day workshop.
2. Design the cell using course concepts as a floor exercise by:
   - Establishing a machine footprint
   - Observing time, both by operator and machine
   - Designing the specific cell.
3. Get management approval of the cell design.
4. Move machines to the cell (evening of Day 2).
   - Wire and plumb as necessary.
5. Start the cell (Day 3).
6. Revise the cell (Day 4 and 5).
   - New footprint involving the operators
   - Move the equipment again.
7. Develop standard kanban sizes for daily schedules.
8. Perform setup reduction if needed to meet the takt time.
9. Reroute conveyor lines for material transport as necessary.
10. Begin continuous improvement activities to enhance the cell.
    - Kaizen principles
    - Make things easier for operators
    - Balance manual work.

Implementation Vignettes

As cell implementation progressed, a variety of stories emerged that reinforced the direction that the LED was going. All the cells were designed with equipment close together so they could be operated, if required, with one person in a "chase" mode — the single operator would "chase" a part through the entire process. If volume dictated two or three people per cell, they could continue to use the "chase" method; or they could sub-divide the cell so that each person would operate a "zone" of machines.

When there was a little confusion early on about the "chase" approach, Joe Schmidt, supervisor in the cover cell, compared it to plowing a field with his father and his older brother. His dad would operate the first plow, his older brother was just behind and offset, operating the second plow, while Joe himself brought up the rear on the third plow, enabling all of them to all plow in synchronization. End of confusion.

It was in this same cell that the takt time slowed down a drilling operation in order to keep synchronization with the one-piece flow, in contrast to the old way of pushing for maximum machine speed. The old way caused the drill to "punch" a hole in a cover. In the new cell, the drill could now "cut" the material as required. Tool life quadrupled and the quality improved with no loss in production.

Joe was also heavily involved in the cover cell design with Mike Krawczyk and helped develop standard flow and setup procedures. One of his proudest accomplishments, however, was the "poka yoking" or fail-safing and "operator-friendly" improvements on a J & L Fay lathe that turned and faced an asymmetrical cover that had tight tolerances. As part of setting up the cell, Mike designed an expanding chuck to reduce runout to under .001 in. on the facing and turning operation done on this machine. The last step was to air blow chips out of a previously tapped hole. In order to fail-safe the completion of this step, an alarm on the lathe safety door would sound if the sequence of turn and face then air blow was broken. Also, since the part was asymmetrical, it could only be unloaded from one orientation on the lathe. Joe designed a stopping motor that automatically oriented the part for unloading, simultaneously balancing the holding chuck and the piece; this greatly reduced machine chatter and bearing wear. As a final touch he incorporated a work light in the chuck area so the operator could see the lathe fixturing better. "This new way of working is so much better. I used to spend 80 percent of my time scheduling. I have fun constantly improving the operations," he said. It is this kind of attention to all steps in the process makes JIT cells successful.

Crankshaft lines for each focused factory dramatically reduced leadtimes. The old way of manufacturing crankshafts in batch, the 20-step process, took two-three weeks. The flow principle of "make-one piece move-one piece," reduced machining to 30-45 minutes. In the large twin crankshaft cell a small mono rail was built into the operation to tie the machines together in series because a 20-pound crankshaft could become very heavy by the end of the shift.

The carburetor machining and assembly cell was an interesting challenge as an outside contractor had submitted a "bid" to supply carburetors directly to the lines at a cost 40 percent lower than the internal costs to produce them. Mac met with the operators and told them that to be competitive internally, they had to make the same volume with 45 percent fewer people. They accepted the challenge. Even though the lower-seniority employees knew they would end up elsewhere, they worked just as hard to achieve the productivity gains required. Part of the revised cell design included a clever approach to match the upper and lower carb chamber

Results

Productivity

Cell problem areas became more visible, easier targets for continuous improvement.

Work environment became more worker friendly.

Material Handling

Fork truck operators reduced; fork lifts reduced from hundreds to two.

Work in process inventory reduced from 500,000 to less than 2000 engines.

Computer inventory tracking almost totally eliminated.

Shop expediting reduced as one cell is managed, compared to up to 30 machines.

Shop supervision reduction of 60 percent time spent on individual operations compared to one cell. Shop supervisors freed up for value-added work such as setup reduction, quality improvements and Kaizens.

Parts containers for parts in process reduced from hundreds to zero.

Floor space reduced from 800,000 to less than 400,000 square feet.

Cost of quality improvements include reduction of rework and scrap; reject rates dropped from 8-10 percent to less than .2 percent.

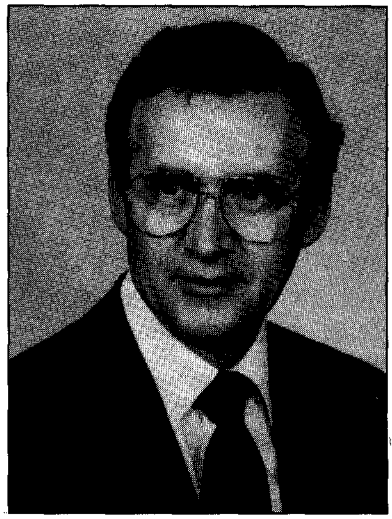
Operator quality check time reduced or eliminated by fool-proof devices.

Leadtimes reduced from 15-20 days to minutes; customer response dropped from weeks to one day.

Setup changeovers eliminated or cut to less than ten minutes.

Tool costs dropped as speeds and feeds of mills and drills lengthened tool life two and four-fold.

A Tribute to Mac McCulloch



Mac McCulloch, AME Member No. 29.

Ten years ago on weekly trips out to Briggs and Stratton, my teammates and I witnessed cracks developing around the edges of this American success story. Briggs and Stratton engines were known for quality and reliability; the production system was designed for high volumes to feed worldwide demand. Huge assembly and feeder plants brought generations of factory workers a prosperous life-style that filled the parking lot with big American cars and American motorcycles, and a few RVs.

Internally, the Briggs and Stratton production system had worked well for many years. I was struck by the size of it all — mile-long assembly lines, the equally large production and materials planning departments. Within the complex network of feeder plants and the supporting planning organization, it was hard to find a beginning or an end. MRP, an algorithm-riddled mystery, had a lock on the system; everything happened serially, nothing was in parallel. No sooner had purchasing placed hundreds of orders for next season's materials, when a flood of change orders changed their paperwork.

Back in a corner cubicle of the MIS department lived Mac McCulloch. He, Nick Edwards, Bill Wheeler, Doc Hall, and a few other radical APICS members had started gathering interest in their Repetitive Manufacturing Group (RMG). For weeks at Rath & Strong, all I heard about was the Kawasaki workshop this, and the RMG that. It was the beginning of a complete redesign of the production system — machines and people both.

Through it all Mac kept building. One of the hobbies that will continue to occupy his energies after his upcoming departure from Briggs and Stratton is making Queen Anne furniture. During those days, Mac's cutting and fitting was big-scale; he was for a time (according to teammate Edwards), a prophet without a following.

Mac's vision moved Briggs and Stratton and AME along. He saw what could be and kept trimming and fitting until others saw, too. Good work, Mac.

Patricia E. Moody

Patricia E. Moody,
Editor

---

castings as a pair, saving a 100 percent check for matching. They also made significant productivity gains using a "chuka-chuka" principle of automatic unloading. In a normal multi-machine cell an employee must unload a work station before he or she can load the new part. With automatic machine unloading, the operator only concerns himself with the loading of a part, resulting in a significant productivity gain. Briggs used this approach in the crankshaft and cylinder machining stations.

Employee Attitudes

Many interesting shifts occurred in employee attitudes. Instead of being a small cog lost in a big operation, employees "belonged" to a line for which they shared responsibility. This attitude evidenced itself during a factory tour when an employee commented, "We've got to get back to the foundry — we've got a slight pattern shift causing excess material on a casting and it's causing tool chatter in the cell." People began to appreciate the value of teams. Penny Ford, Leora Smith's partner in the cover cell, commented, "A good cell team partner is key." Leora added, "This is the best cell I have worked in!"

As LED implemented more cells the people began to realize there was a different way of making product in synchronized flow rather than batches. One employee commented, "We should have some of the world's healthiest employees" because operators walked their parts from the beginning to the end of the cell. As employees have gained experience, they have revised some cells up to three times so far. Continuous improvement never stops.

The final assembly lines also made significant improvements, not only eliminating unnecessary handling, but also in quality, especially in paint. By shifting from a wet paint process to an electrostatic process, paint defects were dropped. People became more flexible, able to operate up to five different jobs in the line. There was a continual challenge to improve operations as operators believe, "If I always do what I've always done, I'll always get what I always got!" The ethic became, "If a step doesn't add value, it's adding waste."

Results

Over the first three years, results are impressive. Most importantly, the overall space required for LED was reduced by 50 percent from 8000 sq.ft. to 4000 sq. ft. Typical of space reductions were the aluminum cover cell where the square footage went from 3200 sq. ft. to 1000 sq. ft. Scrap and rework has been reduced by over 30 percent, and quality, as measured by defects, has been improved by a factor of greater than ten. Even though significant automation and repetitive manufacturing techniques had been used for many years, the improved product flow reduced material handling and increased productivity substantially.

Dutch Vandervort, a senior setup man for the piston and rod machining area said, "This has to be a lot easier for the company to find the real cost of individual parts. In my opinion, the most beneficial thing that came with divisionalization was employee involvement. There is a tremendous amount of experience here — employees with 24 and more years of service; and the company can tap into that experience," he continued. "When there is a problem the operators come up with changes that have impressed me ... There have been large savings from reduced downtime and scrap. We have a long way to go but the company can save a bundle using employee input."

When Greg Socks was asked, "Now that you have been on this world-class journey for three years, what would you change or do differently, and what did you do well?" he responded:

Changes:

1. More training for everyone — especially middle management, the group most threatened by change.
2. Implement preventative maintenance sooner.
3. More communication. Even though communication is 1000 percent better than in the past, we still need 100 times more on top of the 1000 percent.
4. Develop more champions early on.

What we did well:

1. We created an environment to support change.
2. All stakeholders were actively involved in developing the plan and setting goals and expectations.
3. We did well on reducing the impact of change on people.
4. We did not interrupt delivery to the customer. It requires planning and people to develop 50 machine cells, and to move 2500 machine tools without interrupting production.

The key to success has been a well thought-out strategy and plan, and active employee involvement. This journey will never be finished, for as long as there are non value-added activities remaining, there will always be challenges for the continuous improvement teams. Greg commented, "This could never have been achieved without the creative energy of our people. As we solve the problems, ten more surface just as tough as the first ten. Sometimes we go backward before we go forward, but no one ever said it was going to be easy. There is no other choice!"

Acknowledgments:

Thanks to Don Geis, Robert W. (Doc) Hall, Mac McCulloch, and Tricia Moody for their input to this article.

Nick Edwards has been a manufacturing management consultant for over 25 years, first with Rath and Strong, and now with Coopers and Lybrand, based in Massachusetts. His industry experience includes eight years as head of Sprague Electric Quality Assurance in the semiconductor division. He is one of the founders of the Repetitive Manufacturing Group which became AME — his membership number is 82.

For information on reprints, contact:
Association for Manufacturing Excellence
380 West Palatine Road
Wheeling, IL 60090
708/520-3282